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Re-instatement of *Sorbus harrowiana* (Rosaceae), based on morphometric analysis

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Abstract

Sorbus harrowiana (≡*Pyrus harrowiana*), previously considered a synonym of *Sorbus insignis* (≡*Pyrus insignis*) in the *Flora of China*, is re-instated here and shown to be distinct from *S. insignis*, based on morphometric analysis, coupled with herbarium and field investigation. We also present for the first-time full descriptions, distributional records and notes for *S. harrowiana* and *S. insignis*.

Keywords

George Forrest, herbarium research, morphometric analysis, *Pyrus*, taxonomy

Introduction

Sorbus L. *sensu lato* (Rosaceae) contains approximately 260 species that widely occur in the temperate zone of the Northern Hemisphere (Yü and Lu 1974; Phipps et al. 1990; Aldasoro et al. 1998; Lu and Spongberg 2003). However, recent research using both molecular (Campbell et al. 2007; Lo and Donoghue 2012) and morphological evidence (Zheng and Zhang 2007) suggests that *Sorbus sensu lato* is polyphyletic. *Sorbus* has been separated into six distinct genera: *Aria* (Pers.) Host, *Chamaemespilus* Medikus, *Micromeles* Decaisne, *Torminalis* Medikus, *Sorbus sensu stricto* and *Cormus* Spach. *Sorbus* L. *sensu stricto* (Rosaceae) comprises ca. 80 species which are delimited from the

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aforementioned genera by their pinnately compound-leaves and are mainly distributed in the Northern Hemisphere: one or two species in Europe, seven species in North America and ca. 70 species throughout Asia (Hooker 1878; Warburg and Kárpáti 1968; Phipps et al. 1990; Lu and Spongberg 2003; McAllister 2005; Zika and Bailleul 2015).

Many species within *Sorbus* are difficult to delimit, including *S. insignis* (Hook. f.) Hedl. (≡*Pyrus insignis* Hook. f.), which bears similarities with *S. harrowiana* (Balf. f. & W. W. Smith) Rehd. (≡*Pyrus harrowiana* Balf. f. & W.W. Smith) in fruits and strong branchlets.

Sorbus insignis was first published by J. D. Hooker and C B. Clarke (Hooker 1878) in the genus *Pyrus* (≡*Pyrus insignis* Hook. f.), based on the collections from the Sikkim Himalaya. In the protologue, Hooker (1878) described *S. insignis* as a small, very robust tree with 4–6 paired leaflets per compound leaf and leaflet blades 3–4 inches (ca. 7–10 cm) long. Then, Hedlund (1901) transferred it to the genus *Sorbus*, based on its pinnately compound-leaves.

Sorbus harrowiana was described on a single George Forrest collection from the Yunnan, south-western China. In the protologue, Rehder (1920) emphasised the large leaflets which often exceed 8 inches (ca. 20 cm) in length and stated that *S. harrowiana* is markedly different from *S. insignis*, although the exact differences were not mentioned. Most taxonomists followed his opinion and considered the two to be distinct species (Yü and Lu 1974; Long 1987; Phipps et al. 1990; Kress et al. 2003; McAllister 2005; Watson and Manandhar 2012).

Gabrielian (1978), however, treated *S. harrowiana* as a synonym of *S. insignis* in the taxonomic and nomenclatural works of the genus *Sorbus* in western Asia and the Himalayas, but gave no detailed explanation. This treatment was subsequently adopted in the *Flora of China* (Lu and Spongberg 2003) and Tropicos (https://www.tropicos.org). During our taxonomic research on *Sorbus*, we found that these two species are easily identified and distinguishable in terms of morphological characteristics and geographical distribution. Herein, we evaluate the morphological variation between *S. insignis* and *S. harrowiana* through a morphometric study of herbarium specimens to establish the delimitation and validity of the two species and to produce a taxonomic treatment including descriptions and distributional notes.

Materials and methods

Plant material and characters scored

Herbarium specimens were studied at A, CAS, CDBI, GH, E, IBSC, K, KATH, KUN, LBG, MO, P, PE, TI and WU (abbreviations according to Thiers 2019). Leaflet length, width and length/width ratio (l/w ratio) were chosen as the morphometric variables to be measured amongst 133 specimen sheets (17 of *Sorbus insignis* and 116 of *S. harrowiana*) in 56 collections from across the range of their geographic distribution (Suppl. material 1: Table S1). Two to four compound leaves were randomly

selected from each specimen. Two middle leaflets from each compound leaf were selected for measurement. A total of 1323 leaflets were measured (141 of *S. insignis* and 1128 of *S. harrowiana*).

Statistical analyses

Normality of the QN standardised variables was tested using the Shapiro and Wilk test (Mahibbur and Govindarajulu 1997), with statistically-significant differences set by the p value < 0.05. Length and width data did not fit a normal distribution, even after $\log_{10}$- or square root- transformation, with only l/w data fitting a normal distribution after $\log_{10}$ transformation. As such, we performed analyses using both non-parametric Wilcoxon signed-rank tests on untransformed data and parametric Welch Two Sample T-tests on $\log_{10}$ transformed data as T-tests are considered robust to non-normality when large sample sizes are used. The analyses were performed in R version 4.0.2 (R Foundation for Statistical Computing, Vienna, AT). The data matrix for analysis was prepared in Microsoft Excel 2011 and is available on request.

Results

Morphometric analysis

Both the non-parametric Wilcoxon signed-rank tests on untransformed data and parametric Welch Two Sample T-tests on $\log_{10}$ transformed data found highly significant ($p < 0.001$) differences between *S. harrowiana* and *S. insignis* in terms of middle leaflet length, width and l/w ratio (Fig. 1). Further detailed examination revealed other morphological characters, such as number and spacing of leaflets on the compound leaves and leaflet shape, venation and indumentum, that differentiate these two species: *Sorbus insignis* possesses pinnately compound leaves with 7–16 leaflets, leaflets at intervals of 1–2 cm, oblong or oblong-lanceolate, 5–8 × 1.5–2.0 cm, middle leaflets l/w ratio 3.3–4.0, lateral veins 24–30 pairs, both surfaces tomentose when young, glabrescent with age. *Sorbus harrowiana* has pinnately compound leaves with 5–7 leaflets, leaflets at intervals of 1–2.5 cm, oblong, 10–18 × 2.5–3.5 cm, middle leaflets l/w ratio 3.5–4.5, lateral veins 19–21 pairs, both surfaces glabrous. Our critical observations and morphometric analyses of herbarium specimens (including type pictures) demonstrate that *S. harrowiana* should be recognised as distinct from *S. insignis*.

Taxonomic treatment

***Sorbus insignis* (Hook. f.) Hedl., Kongl. Svenska Vetenskapsakad. Handl. 35(1): 32. 1901.**

≡*Pyrus insignis* Hook. f., Fl. Brit. India 2(5): 377. 1878.

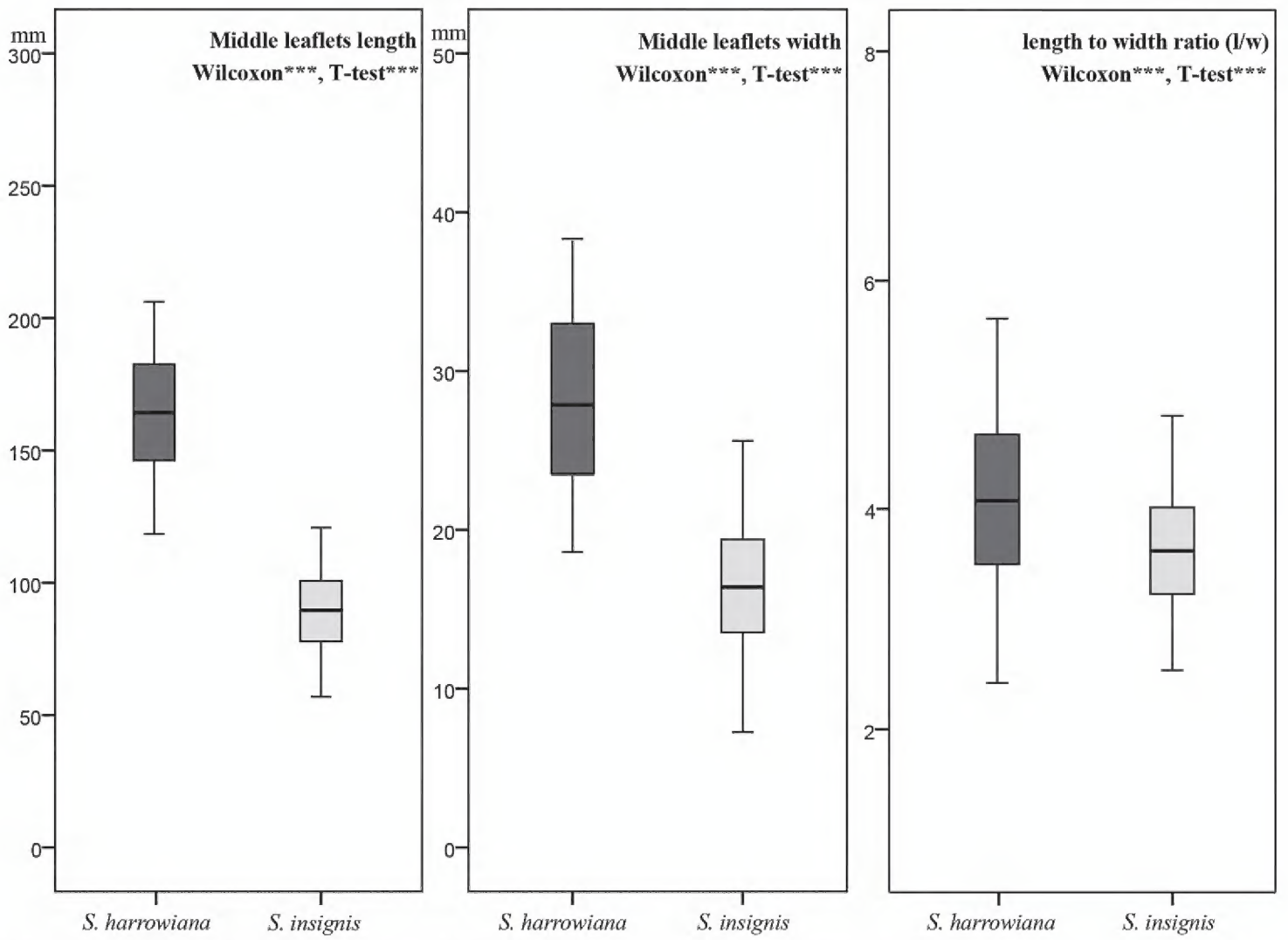

Figure 1. Box plot of comparisons between *S. harrowiana* and *S. insignis* in middle leaflet length, width and l/w ratio. Significant differences found upon analysis using non-parametric Wilcoxon rank sum test on untransformed data (Wilcoxon) and parametric Welch Two Sample T-test on $\log_{10}$ transformed data (T-test) are noted within the figures (*** = $p < 0.001$).

Type. India. **Sikkim:** 8000–11000 ft [2438–3353 m alt.], *J.D. Hooker & C.B. Clarke s.n.* (holotype: K (K000758177 [image!])). Fig. 2A.

Description. Trees or shrubs. Stems greyish-brown; bark grey; branchlets greyish-brown when old; rusty brown tomentose when young, glabrous when old; winter buds narrowly ovoid, 1.0–1.8 cm long, scales initially puberulent, glabrate later; apex shortly acuminate or acute, brownish. Leaves pinnately compound, 15–20 cm long; stipules persistent, suborbicular, sometimes lobed, 1–2 cm wide, margin entire or serrate with pointed teeth; petiole 1.7–4.0 cm long, glabrous; rachis sparsely tomentose, glabrous when old; leaflets 7–16, at intervals of 1–2 cm long, oblong or oblong-lanceolate, 5–8 × 1.5–2.0 cm, l/w ratio 3.2–4.2, middle leaflets l/w ratio 3.3–4.0, lateral veins 24–30 pairs, margin slightly revolute and shallowly crenate, base rounded or obliquely cordate, apex obtuse, both surfaces tomentose when young, glabrescent. Inflorescences compound corymbs, 30–80 flowered, 8–12 cm in diam., peduncles sparsely pubescent; pedicels 2–4 mm long, sparsely pubescent; flowers 6–8 mm in diam.; hypanthium abaxially pubescent; sepals triangular, ca. 1.5 mm long, glabrous or somewhat puberulous, apex acute, with reddish dentate glands along margin; petals creamy white, suborbicular, ca. 4 × 3 mm; stamens

Figure 2. Type pictures of *Sorbus insignis* (Hook. f.) Hedl. (**A** barcode K000758177) and *S. harrowiana* (Balf. f. & W. W. Smith) Rehd. (**B** barcode E00072735).

ca. 20; carpels 3(–4); styles 2 or 3, 2.5 mm. Infructescence sparsely pubescent or glabrous; pomes green when young, white or crimson when mature, globose or ovoid-globose, 5–8 mm in diam., sepals persistent erect; seeds brownish, reniform, 1.5–2.0 mm long; 2n = 34.

Phenology. Flowering May–June; fruiting Sep–Oct.

Distribution and habitat. *Sorbus insignis* is distributed in India, Nepal and China (Xizang) (Fig. 3). It is also mentioned as occurring in 'NW Yunnan' China (Lu and Spongberg 2003), but we have not yet seen any convincing specimens from Yunnan. All specimens labelled as '*S. insignis*' from Yunnan that we have examined were misidentified. It grows in broad-leaved forests on rocky slopes with an altitudinal range between 2500 and 3100 m.

Additional specimens examined. China. Xizang province: Motuo, 2900 m alt., 25 Oct 2016, *B. Xu et al. YLZB4493* (CDBI); Galung La, 2700 m, 18 Aug 1982, *S.Z. Cheng & B.S. Li 0200* (PE).

India. Manipur state: Sirohifurar, 2500 m alt., Jan. 1982, *G. Watt 5965* (P); Ching Sow, 2400–2700 m alt., 16 April 1982, *G. Watt 6539* (P); **Sikkim state:** *T. Thomson s.n.* (E).

Nepal. Eastern Nepal: Sankhuwasabha, 29 Oct 1963, *H. Hara et al. 6301809* (TI); Kuwa Pani, 2890 m alt., 23 Aug 1997, *S. Noshiro et al. 9755184* (A, E); Kauma,

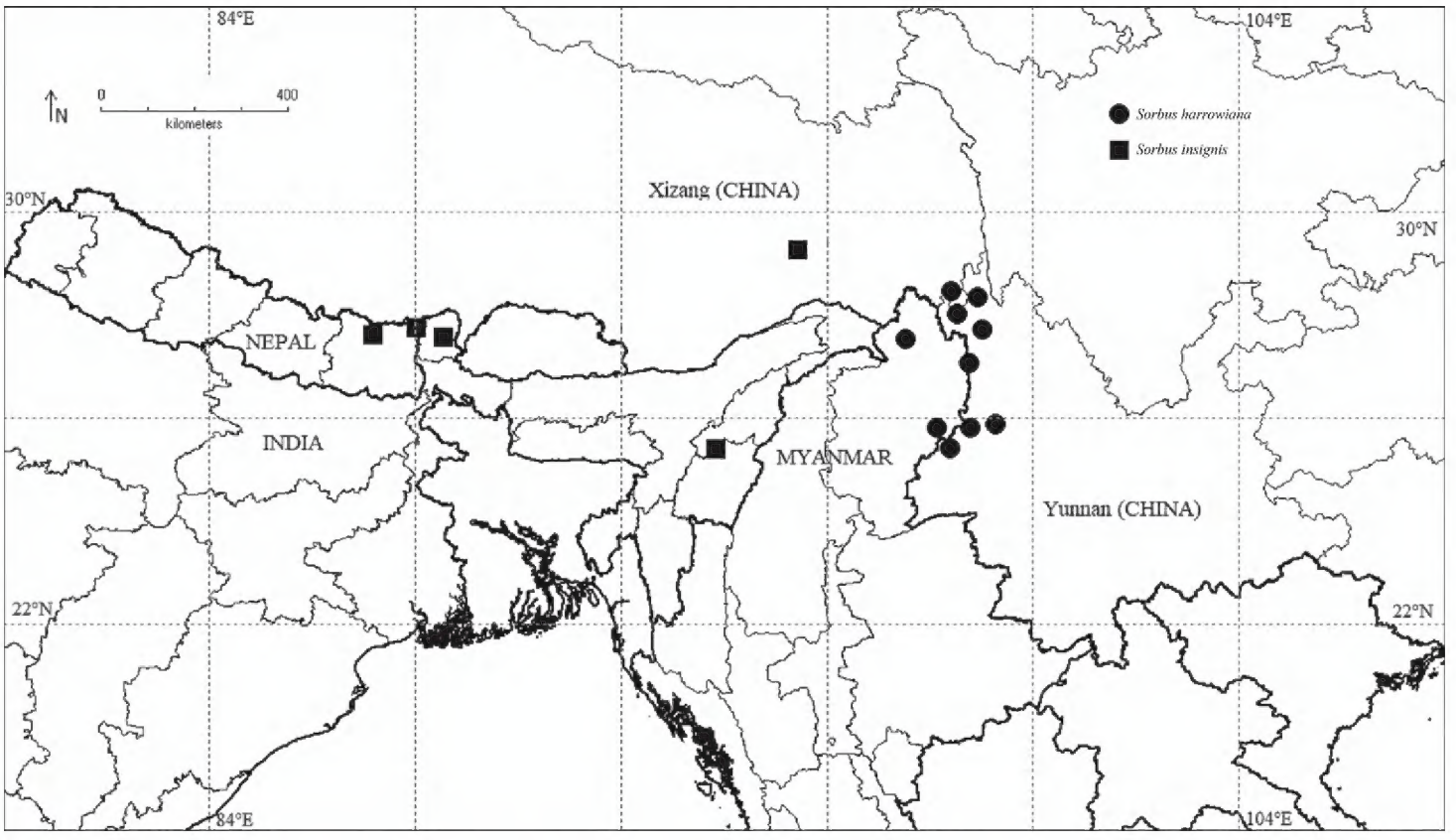

Figure 3. Distribution of *Sorbus insignis* and *S. harrowiana* at county level.

3130 m alt., 25 Sep 1991, *Edinburgh Makalu Expedition 259* (E, KATH); Koping, 3040 m alt., 24 Oct 1991, *Edinburgh Makalu Expedition 1019* (E); Jhakpu, 2750 m alt., 26 Sep 1971, *P.R. Shikyo & M. Ohsawa 1069* (KATH); Bhyaha, 2880 m alt., 31 Oct 1981, *P.R. Shakya 7296* (KATH); Taplejung, 2700 m alt., 30 Sep 1981, *P.R. Shakya 6777* (KATH).

***Sorbus harrowiana* (Balf. f. & W. W. Smith) Rehd., J. Arnold Arbor. 1(4): 263. 1920.**

≡*Pyrus harrowiana* Balf. f. & W.W. Smith, Notes Roy. Bot. Gard. Edinburgh 10 (46): 61–62. 1917.

Type. China. **Yunnan:** Western flanks of the Shweli-Salwin Divide (Tenchong County?), 2800 m alt., 15 Aug 1912, *George Forrest 9040* (holotype: E (E00072735 [image!]); isotypes: A (A00046014!), E (E00010858 [image!], E00072736 [image!]), K (K000758123 [image!])). Fig. 2B.

Description. Small trees or shrubs. Stems greyish-brown; bark grey to bronze; branchlets glabrous; winter buds conic, 1.5–2.0 cm long, scales glabrous; apex acute, reddish-brown. Leaves pinnately compound, 15–25 cm long; stipules persistent, suborbicular, 1–2 cm, margin toothed; petiole 2.0–4.0 cm long, glabrous; rachis sparsely tomentose, glabrous when old; leaflets 5–7, at intervals of 1–2.5 cm long, oblong,

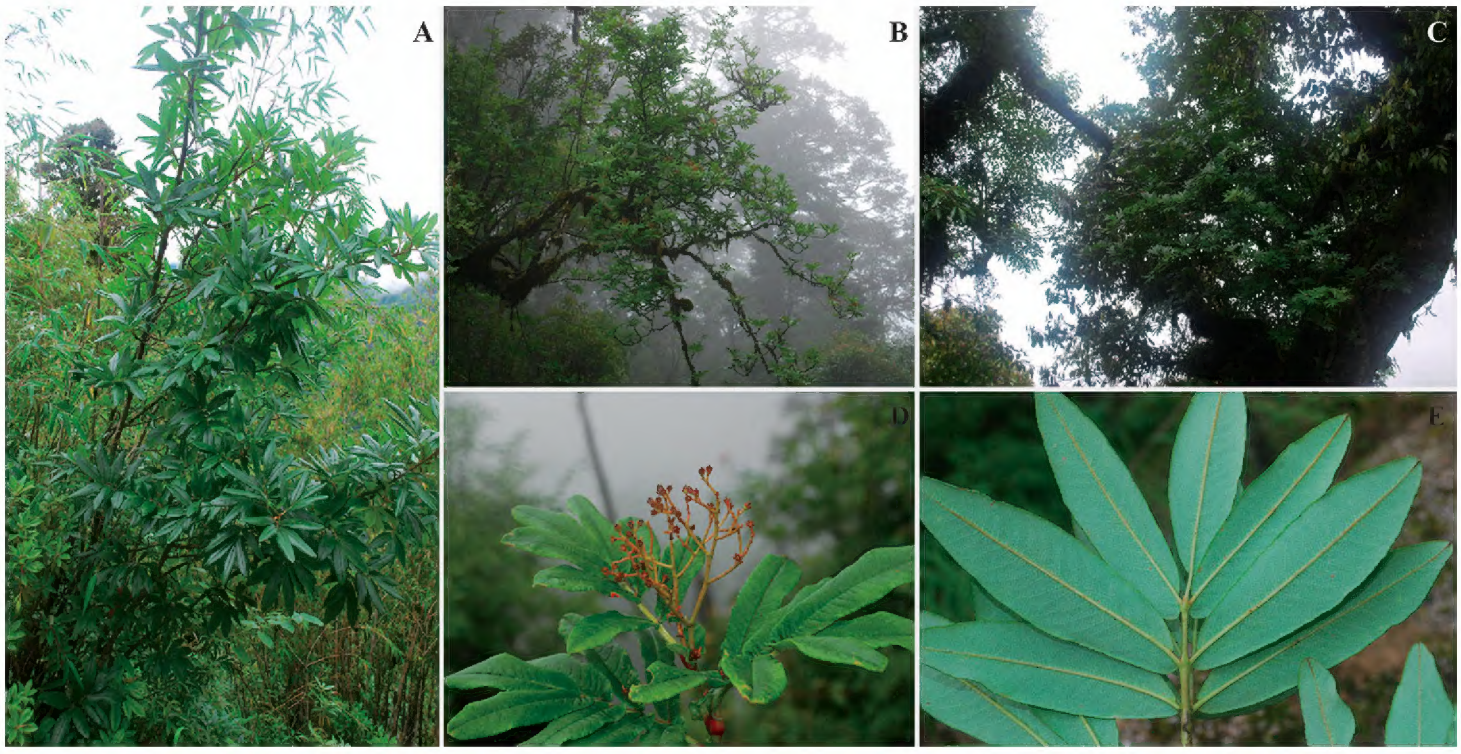

Figure 4. *Sorbus harrowiana* **A** growing near the road in mixed forest **B** growing on a steep forested slope above road **C** growing on *Lithorcarpus* like an epiphytic shrub **D** fruiting branch **E** pinnately compound-leaves.

10–18 × 2.5–3.5 cm, l/w ratio 3.2–4.6, middle leaflets l/w ratio 3.5–4.5, lateral veins 19–21 pairs, margin slightly revolute and shallowly crenate, base rounded or obliquely cordate, apex rounded, both surfaces glabrous. Inflorescences compound corymbs, 30–200 flowered, 12–20 cm in diam., peduncles sparsely pubescent or glabrous; pedicels 3–6 mm, sparsely pubescent or glabrous; flowers 6–9 mm in diam.; hypanthium abaxially pubescent; sepals triangular, ca. 2.0 mm long, glabrous or somewhat puberulous, apex acute, with serrate along margin; petals creamy white, suborbicular, ca. 4 × 4 mm; stamens ca. 15–25; carpels 3(–4); styles 2–4, 2–4 mm. Infructescences sparsely pubescent or glabrous; pomes creamy-white rarely pink, globose or ovoid-globose, 5–7 mm in diam., sepals persistent erect; seeds brownish, reniform, 1.5–2.0 mm long; 2n = 34.

Phenology. Flowering May–July; fruiting Sep–Oct.

Distribution and habitat. *Sorbus harrowiana* is distributed in China and Myanmar (Fig. 3). It grows in broad-leaved forests with an altitudinal range between 2100 and 3300 m. (Fig. 4).

Additional specimens examined. China. Yunnan province: Deqin, Cizhong, 2800 m alt., 8 Oct 1959, *K.M. Feng 23997* (KUN, PE); Fugong, Lumadeng Xiang, 3100 m alt., 13 Aug 2005, *Gaoligong Shan Biodiversity Survey* (*G.S.B.S.*) *27252* (CAS, GH, KUN); Biluo Mountain, 2800 m alt., 28 May 1982, *Qinghai-Tibet Expedition 6939* (KUN, PE); Yaping pass, 2884 m alt., 2 May 2002, *G.S.B.S. 20209* (CAS, E, GH, KUN, MO); Yaduo Cun, 2700 m alt., 6 Aug 2005, *G.S.B.S. 26500* (CAS, GH, KUN); Shibali, 2700 m alt., 15 Aug 2005, *G.S.B.S. 28304* (CAS, GH,

KUN); *G.S.B.S. 28409* (CAS, GH, KUN); Gongshan, Bingzhongluo, 2530 m alt., 1 Sep 2006, *G.S.B.S. 31826* (CAS, E, GH, MO, KUN); 2700 m alt., 25 Jul 1982, *Qinghai-Tibet Expedition 7512* (KUN, PE); Zguziluo, 2800–3000 m alt., 25 Jun 1978, *Bijiang Expedition 1009* (KUN); Champutung, 3000 m alt., Oct 1935, *C.W. Wang 67581* (A, KUN, LBG, NAS, PE, PE, WUK); Dulongjiang, 2700 m alt., 21 May 1991, *Dulongjiang Expedition 7022* (KUN); Kongdang, 3030 m alt., 28 Sep 2002, *G.S.B.S. 16655* (CAS, E, GH, KUN); Labadi, 2970 m alt., 30 Sep 2002, *G.S.B.S. 16792* (CAS, E, GH, KUN); Pula river, 3100 m alt., 3 Oct 2002, *G.S.B.S. 16906* (CAS, E, GH, KUN); Fucai, 2780 m alt., 1 Sep 2006, *G.S.B.S. 31772* (CAS, E, GH, MO, KUN); Yidongwei, 2530 m alt., 1 Sep 2006, *G.S.B.S. 31826* (CAS, E, GH, MO, KUN); Mangzhou Wadi, 3010 m alt., 12 Aug 2006, *G.S.B.S. 33217* (CAS, E, G, KUN); Qi-Qi Nature Reserve Station, 3200 m alt., 16 Oct 1996, *G.S.B.S. (1996) 7803* (E); Dong Shao Fang, 3100 m alt., 21 Sep 1997, *G.S.B.S. (1997) 9495* (E, MO); Danzhu river, 2750 m alt., 1 Jul 2000, *H. Li et al. 11855* (CAS, E GH, KUN); Dulong Jiang valley, 2770–3050 m alt., 15 Jul 2000, *H. Li et al. 12614* (CAS, E, GH, MO, KUN); Su Ki Tung, 1923, *J. Rock 10161* (A); Mt. Kenyichunpo, 10000 ft [3048 m alt.], Jul 1923, *J. Rock 22068* (A, E); Ci-kai, 07 Oct 1940, *K.M. Feng 7946* (KUN, PE); East Check Point, 2700 m alt., 22 Jul 1982, *K.M. Feng 8226* (KUN, PE); Wangtzang, 2800 m alt., 13 Sep 1938, *T.T. Yü 20216* (A, E, KUN, PE); Swangchiang, 13 Jul 1938, *T.T. Yü 22088* (A, E, KUN, PE); Lushui, 2800 m alt., 6 Jul 2016, *Meng Li et al. GYD0058* (CDBI); Tenchong, Mingguang Xiang, 19 May 2006, 3000–3050 m alt., *G.S.B.S. 29157* (CAS, E, GH, KUN); Zizhi Cun, 2750–2850 m alt., 19 May 2006, *G.S.B.S. 29224* (CAS, E, GH, MO, KUN); Jiangao Shan, 3020 m alt., 23 May 2006, *G.S.B.S. 30546* (CAS, E, GH, MO, KUN); Weixi, 2900 m alt., 13 Oct 1934, *H.T. Tsai 59790* (A, IBSC, KUN, P, PE); 2800 m alt., 20 Oct 1934, *H.T. Tsai 59902* (A, IBSC, KUN, LBG, PE); Biluo Snow Mountain, 3250 m alt., 11 Jul 1981, *PE Hengduan Mountain Collection Team 01402* (PE); Cangjiang river, 3300 m alt., 18 May 1940, *K.M. Feng 3965* (KUN, PE); Baimaluo, 3200 m alt., 3 June 1940, *K.M. Feng 4429* (KUN, PE); Yanwa, 3600 m alt., 11 May 1960, *Kunming Workstation of Institute of Botany 8375* (KUN, PE); Kangpucheda, 3000 m alt., 8 Oct 1956, *P.I. Mao 385* (KUN, PE); Magelo, 23 Aug 1956, *P.I. Mao 401* (KUN, PE); Bading, 3500 m alt., 11 May 1982, *Qinghai-Tibet Expedition 6434* (PE); Yunlong, Nu Shan, 2 Nov. 1993, *K.D. Rushforth 2663* (E); **Xizang province:** Chayu, 10000–11000 ft [3048–3353 m alt.], June 1922, *G. Forrest 21806* (A, E, P); Oct. 1922, *G. Forrest 22870* (A, E).

Myanmar. Kachin state: Myitkyina, 3050 m alt., 19 Oct 1919, *R. Farrer 1403* (E); *G. Forrest 24481* (E, PE); Chimili, *G. Forrest 26813* (A, E); *G. Forrest 27541* (A, E); *G. Forrest* 29775 (E, PE); Putao, 2800 m alt., 16 May 1953, *F. Kingdon-Ward 20921* (E); Tata Bum, 3000 m alt., 19 June 1953, *F. Kingdon-Ward 21009* (A, E); Trails above Camp 3, 3000–3140 m alt., 22 Oct 2013, *Hponyin Mountains Expedition 206A* (E); Adung velly, *F. Kingdon-Ward 9568* (A).

Key to species in *Sorbus* Ser. *Insignes* Yü.

Note. George Forrest made seven major expeditions to western China and north-eastern Myanmar during 1917 and 1931, with over 30,000 collections being made. In these expeditions, G. Forrest collected at least 23 specimens of *Sorbus harrowiana*, of which 15 lacked locality information. However, from limited collection information, we are able to broadly georeference these 15 specimens to four different regions (as he mentioned in the collection record), i.e. (1) China: Yunnan: Shweli-Salwin divide, *G. Forrest 15888* (E, P), *G. Forrest 16101*(E), *G. Forrest 18506* (E), *G. Forrest 24373* (E, P, PE), *G. Forrest 26778* (A, E); (2) China: Yunnan: N'mai kha-Salwin divide, *G. Forrest 18527* (E, P), *G. Forrest 18753* (E); (3) China: Yunnan: Salwin-Kui Chiang divide, *G. Forrest 25687* (E, PE), *G. Forrest 25768* (E); (4) China: Yunnan, *G. Forrest 19874* (E), *G. Forrest 20849* (E), *G. Forrest 20869* (E, P), *G. Forrest 21806* (A, E, P), *G. Forrest 29015* (E, PE), *G. Forrest 30374* (E, PE). The specimens examined by us also covered those four regions.

1 Leaflets, Inflorescences and infructescence pubescent..... ***S. helenae*** **Koehne**

– Leaflets, inflorescences and infructescence glabrous..... **2**

2 Leaflets 7–16 per compound leaf, 5–8 × 1.5–2.0 cm, oblong or oblong-lanceolate, lateral veins 24–30 pairs, both surfaces tomentose when young, glabrescent with age ..... ***S. insignis***

– Leaflets 5–7 per compound leaf, 10–18 × 2.5–3.5 cm, oblong, lateral veins 19–21 pairs, both surfaces glabrous..... ***S. harrowiana***

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Supplementary material 1

Table S1. Accessions of herbarium specimen for measurements

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Data type: measurement

Explanation note: .

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